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ABSTRACT

The report describes a project examining computer-assisted instruction for severely/multiply handicapped students. An underlying thrust of the project was to provide multiply handicapped children with opportunities to learn to control events as part of their daily activities. The approach featured 26 pupils (5-21 years old) using three activities: a single-switch cause-and-effect task, a two-switch cause-and-effect discrimination task, and a communication task. Performance graphs are presented and discussion is devoted to individualized adaptations of positioning and apparatus. Findings revealed that 18 of the 26 Ss learned to use a switch to produce interesting consequences. Three of the 18 also learned to distinguish between two switches to reliably use the switch which produced consequences. A second finding was a possible relationship between the pattern of switch use that the children displayed and their cognitive level. There was a modest tendency for pupils to operate the switches with increasing selectivity as their level of sensorimotor functioning increased. Software used in the project is appended. (CL)

Final Report

Development of a Microprocessor Based Workstation for Severely/Profoundly Multihandicapped Students

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Table of Contents

PURPOSE

The overall purposes of this project were to: 1) demonstrate the utility of a microprocessor-based workstation as a vehicle for instruction of severely/multiply handicapped students; 2) to develop and refine as necessary software for a microprocessor-based workstation for use with severely/multiply handicapped children; 3) to adapt manipulanda in ways that accommodate to the children's physical disabilities and permit them to respond to tasks produced at the workstation.

RATIONALE

Powerful instructional strategies that use microprocessors in the education of handicapped children are being developed. The majority of demonstrations of the utility of this technology have occurred with physically disabled youth and adults where microcomputers have been used as adaptive devices that allow for greater independence in activities of daily living (Dahmke, 1981). A growing use is the development of instructional software in the traditional areas of academic skills (Grimes, 1981; Hannaford & Sloane, 1981) for intellectually handicapped children and for school-aged physically handicapped children whose intellectual functioning is unimpaired (Rushakoff & Lombardino, 1983). A group that has yet to benefit from this technology are children with multiple physical handicaps of a

severe degree who are also functioning at a severe to profound level of retardation. In general this group of children has not had much access to microprocessor-based adaptive devices and instructional materials, as their physical limitations do not permit them to operate most available equipment and because very few activities for use with microprocessor-based systems have been developed for children who are functioning at a cognitive level of less than three years of age. However, recent advances in equipment and knowledge now make it possible to provide severely handicapped pupils with developmentally appropriate learning activities that can be presented using a microcomputer.

The rationale for providing physically and sensory handicapped children opportunities to actively engage in learning activities that were previously inaccessible to them comes from a number of sources. Literature on infant learning suggests that children learn and are motivated to interact with their world when they can observe their effect upon it (Yarrow & Pedersen, 1976). Handicapped children, like all children, need opportunities to see the impact of their actions on the environment (Brinker & Lewis, 1982). Investigators of infant development have argued that opportunities to use and extend strategies of control over their physical and social environments are instrumental in the infant's future development of competence (Bruner, 1975; Uzgiris & Hunt, 1975; White, 1959). Studies both from operant and cognitive points of view indicate that infants under six months of age do learn discrete responses (e.g., head turns, foot kicks) in situations where these responses produce an interesting event (Finkelstein & Ramey, 1976; Watson, 1966). Handicapped infants also

display a similar ability to learn simple contingent (cause-and-effect) relationships (Brinker & Lewis, 1982; Robinson & Robinson, 1978; Zuromski, Smith, & Brown, 1977).

Robinson and Robinson (1978) have argued that severely handicapped children who are functioning at a cognitive level of two years or less can benefit from experiences which give them control over simple environmental events. Robinson (1982) has also argued that typical infants have countless experiences during the course of a week in which their behaviors have a systematic effect on those around them. In developing this point she argues that children with physical or sensory handicaps are at a great disadvantage in learning during the sensorimotor period (especially before they understand spoken language) because they have few opportunities to control events (either physical or social) in their environment.

<u>Development of means for obtaining desired environmental events and operational causality</u>. Robinson (1976) and Robinson and Robinson (1978) have argued that the Piagetian Sensorimotor Scales developed by Uzgiris and Hunt have utility for the development of instructional programs for children with severe handicaps who are functioning at the sensorimotor level. The sensorimotor scales of interest in this particular work are those of the development of Means for Obtaining Desired Environmental Events and the Development of Operational Causality. The specific sequence of steps in the development of each of these sensorimotor areas have been outlined by Uzgiris and Hunt in their Ordinal Scales of Psychological Development. These two series start out with very similar behaviors but then beginning at around 3 or 4 months of age begin to differentiate. Robinson (1976) has

suggested that one way of conceptualizing this distinction is to look at the means-ends sequence as opportunities for the child to act on the physical environment so as to produce interesting events. In the causality sequence, the child also acts on the environment to produce an effect but is successful in doing so from the 4- to 12-month levels because his or her actions are interpreted by an adult as having a particular communicative intent. Both of these sensorimotor series would appear to have important implications for the child's development of communication in whatever form that communication takes. Our purposes in providing young severely handicapped children with means to act on their environments are two-fold. One major purpose is, as has been previously stated, to give the child the opportunity for some environmental control. The second purpose has been to provide experiences which would appear to be prerequisites and preparation for the use of alternative types of communication devices, a likely form of communication for most of the children within this population. Our work with severely handicapped children has involved presenting them with means for activating events in their environment. We noted that while many children seem to acquire the ability to activate a switch thus turning on a consequence with reasonable ease, performance in that situation was not adequate preparation for the child to begin to use some type of communication system that involved automation. For children without physical impairments, the intervening steps between basic actions on the environment to produce an effect, either in the means-ends or causality sequence, and use of words to communicate involves more complex kinds of causality and means-ends tasks which demand physical responses of which the motorically

impaired child is not capable. One of our concerns or questions in this current work was whether we could explore variations in the basic operant (behavioral framework) or causality (Piagetian framework) task of hitting a switch and activating something in the environment that would transition the child from the step of, basic action to produce an effect, to the apparently more complex understandings of cause-and-effect relationships and variations in responding that produced different effects that are part of the repertoire of the child who is showing criterion stage 5 or stage 6 performance on the Uzgiris-Hunt Sensorimotor Scales. This level of child is beginning to use words to communicate wants and to request information; communication functions which we would like our severely physically involved children to have, albeit with nonvocal means of communication.

For the physically and/or sensory impaired child, this lack of exposure to responsive toys and the lack of control over events in their lives can have several undesirable effects (Robinson, 1976; Robinson & Robinson, 1978). Lack of access to manipulable and responsive playthings can produce developmental delays in cognitive, communication, and self-help skills because much of the expression of these abilities occurs through the manipulation of the social and physical environment. Second, the motivation of these children to seek interesting playthings may diminish. Clinicians who work with physically disabled children report attitudes of passivity on the part of some children; we are arguing this passivity is, in part, the result of their inability to control significant events in their lives (Seligman, 1975). The importance of learning to interact with and to exercise control over events is not limited to physical objects;

children also learn through interaction with their parents. However, handicapped infants are less effective in acting on their social environment than are non-handicapped children. Jones (1977) reported that Down Syndrome infants make fewer social initiations than non-handicapped babies. Walker (1982) studied deaf-blind infants and found that they were less active and less available for interactions than their non-handicapped peers. Our own experience with children who have severe motor handicaps suggests that they are also less able to engage in mutually satisfying interactions with their parents than are children who have no motor disorder. These observations point to the importance of providing multiply handicapped children with opportunities to learn to control events as part of their daily activities at school and at home.

Issues in Application of Microcomputing Technology With Severely Handicapped

Educators who wish to introduce microcomputing into educational programs for severely and multiply handicapped children face significant problems. First, the availability of software appropriate to the physical and cognitive abilities of our pupil population is quite limited. Second, the limited motor skills of these children do not permit them to operate a keyboard or paddle stick that are standard manipulanda on most microcomputers. Indeed our experience had been that the children with whom we worked in this research project performed optimally only when presented with one or two switches that had been selected specifically for them and carefully placed in order to make use of their most reliable motor response(s). Unfortunately, most microcomputers are not designed to accept signals

from such switches; as a result, interface equipment that will enable microprocessors to accept inputs from a wide variety of switches is needed. Similarly, while the output of most microcomputer-based instructional systems is to a video monitor, we needed a wide variety of events that are reinforcing to children functioning below three years. Such events included lights, recorded music, and battery-operated toys. Here too, we used interfacing equipment that was not usually available with microcomputers in order to have the microcomputer activate these displays.

OBJECTIVES

The objectives of this technology research project were to:

1. Demonstrate classroom utility of a microprocessor-based workstation as a vehicle for sensorimotor instruction for severely/multiply handicapped students.
2. Demonstrate the utility and refine as necessary existing programs available for the microprocessor-based control unit for use with severely and multiply handicapped children.
3. Develop and demonstrate the utility of additional software programs for the control unit workstation that will require more complex levels of cause-and-effect relationships in order to activate the consequences.
4. Examine the relationship between child developmental level and conditionability.
5. Demonstrate the utility of the workstation's use in conjunction with a signalling device.

6. Develop a manual to guide teachers in the classroom use of this equipment and software with severely multiply handicapped children.

APPROACH

A Commodore 64 microcomputer was used to provide severely handicapped and profoundly retarded children with a means of controlling events which they appeared to enjoy. These events, which included tape recorded music, a mechanical bear that beat a drum, a motorized pinwheel, a vibrator pad, bright flickering lights, and a fan, were activated, either singly or in combination, in response to the operation of a switch.

Subjects. A population of 26 pupils participated in this study. These pupils ranged in age from 5 to 21 years with an average age of 9 years. Most had multiple disabilities including sensory handicaps, cerebral palsy, neurological impairments manifested as seizure disorders and severe to profound mental retardation. Precise estimates of their cognitive abilities were difficult as there are no norm-referenced instruments appropriate to this population. The Uzgiris-Hunt Scales (1975) were used to assess the cognitive abilities of the children. Of the 26 subjects, 4 pupils displayed abilities beyond the sensorimotor level, the abilities of the remaining 22 were judged to be within the sensorimotor period, which implies that these 22 had mental ages of 2 years or less. Table 1 provides a description of the subject population.

Table 1

Subject Population Characteristics

Disability	Motor	Seizures	Auditory	Visual	Cognitive
Frequency	17	10	9	16	26
Percent of Total	65	38	31	62	100

Sensorimotor Level	1	2	3	4	5	6	Pre-operational	Unable to assess
Frequency	0	4	2	9	5	0	4	2
Percent of Total	0	15	8	34	20	0	15	8

Pupils attended three school programs. The Multiply Handicapped Children's Program at Meyer Children's Rehabilitation Institute, the Multiply Handicapped Program for elementary school aged children of the Lincoln Public Schools at Hawthorn Elementary School, and the program at the Rose Kennedy School in Council Bluffs.

Curriculum Activities

A major part of our approach has been to develop, for severely handicapped pupils, activities that will allow each student to throw off their status as passive observers and actively participate in the learning process. Ultimately three activities were used in this work. A single-switch cause-and-effect task, a two-switch cause-and-effect discrimination task, and a communication task.

Definition of Tasks

Single-switch task. In this task the child was presented with a single-switch selected and positioned in a manner found to be appropriate for that child. This switch would activate the available consequences on a continuous reinforcement schedule.

Two-switch discrimination task. In this task situation the child was presented with two identical switches which again were selected and positioned in a manner appropriate for the individual child. Once the child reached criterion performance on the consequated switch, that switch was then deactivated from the beginning of the following session and the switch positioned on the other side was then activated. Thus the child through responding to the previously consequated switch would now discover that switch to be ineffective. The typical performance expected was for the child to attempt to activate the consequence by hitting the initially consequated switch

and then to direct his or her responses to the alternative switch. Once a child reached criterion performance on the alternative switch the contingencies would again be reversed. Thus this task was a discriminated operant task.

Delayed consequence task. This task, which could be presented in the single-switch condition, was a task identical to the single-switch task with the exception that the onset of the consequence would be delayed. Thus the child would hit the appropriate switch to activate the toy but the onset of that toy's "performance" would be delayed by a specified number of seconds.

Communication task. In the communication task the child was presented with a signalling device. Initially we anticipated that t. device would be similar to the call button used in situations such as a hospital room or the seat of an airplane. Again, the child would be presented with an appropriately positioned switch which upon activation would turn on a light and a call signal.

Individualized Adaptations

Pupils were evaluated to determine how best to arrange child and equipment in order to facilitate the child's access to the equipment.

Positioning the child. It is characteristic for children with cerebral palsy to have difficulty in the refined control over reach and grasp that is required to activate a switch. Often their ability to balance themselves is also limited. Although very time consuming, it was essential that the children were positioned in a manner that allowed them optimal movement. At times, finding a workable position was decisive in determining whether or not a child was successful in learning to produce displays with the switches. This was often

accomplished with guidance from occupational and physical therapists. However, even with assistance from such specialists, additional work to maximize each child's potential was frequently required.

Most, but not all, pupils operated this equipment while seated. When properly seated, a child's trunk is supported and stable while the child's voluntary movements are minimally impeded. Generally, such positioning for optimal movement is best accomplished when the child's seat and back rest securely against the chair and the child's feet are supported fully by the floor or on a foot rest. When needed, additional support can also be given to the child's head and trunk. In several instances children were strapped into the chair for support, and abduction posts were used to prevent scissoring of their legs. A useful discussion of the principles of positioning children with cerebral palsy may be found in Finnie (1975).

Responses. At least one reliable motor response must be identified. With the limited responses available to some of the children, it is sometimes necessary to search for a single response that is under volitional control. The amount of force and the range of reach must be determined in order to select a response that is readily available. Some pupils have no "normal" motor patterns available with which to operate a switch. At those times the value of being able to operate on the environment must be weighted against the consequences of exercising an abnormal movement pattern (see Robinson, 1982, for a discussion of this point).

It is worth noting that unlike programs that focus on motor learning (e.g., Koheil & Mandel, 1980; Woolridge & McLaurin, 1976), our purpose was not to teach motor skills, nor to encourage the

development of head control or desirable postures. Instead, we have been interested in the development of causality and have tried to optimize each child's use of established motor patterns as a means of accomplishing an effect on the environment previously unavailable to the child and, in so doing, establish a perception of personal efficacy and thus promote an understanding of cause-and-effect relationships.

Switches. It should be evident that the success of this type of program is dependent upon the properties of the switches used. An enormous range of switches that vary in design, cost, and reliability is available. It was important to match the switch to the child's abilities. Several guidelines were used in making selections. Most important, the switch must reliably respond to the child's efforts to operate it. This means that the same motor response should activate the switch each time the child makes the response and, of course, that the switch does not operate itself in the absence of that response. A switch must permit children to make use of their most reliable motor responses. A good switch needs to be durable in order to withstand occasional rough handling by children. Switches that provide secondary feedback when they are operated have an advantage over ones that provide none. This feedback may be in the form of a sound, usually a click, or a rough surface for tactile sensation, or observable movement.

Positioning of switch. After a child has been properly positioned, a reliable motor response identified, and a switch selected, it was necessary to place the switch where the child could gain access to it. Positioning switches in a manner that facilitates the desired motor responses often involved mounting the switch directly to a work

surface, such as a table, a wheel chair tray, or a slant board. Or it may be necessary to place a switch under a child's chin or foot--as required.

Children can become bored both with the displays they produce and with the switch task itself. When performance declines, interest can often be increased by changing the consequences. However, it is possible to reach a point where changes in consequences are insufficient--a point at which the task itself is no longer exciting. At such a point, we have found it more useful to change the task in a major way or eliminate it from the child's schedule rather than continue to search for increasingly powerful consequences in the hope of maintaining the child's performance.

Apparatus

Equipment used at each site in this project included a Commodore 64 microcomputer, Commodore 1541 disk drive, a VIC-REL interface, a 110-volt relay, a monitor, and a printer. The VIC-REL is an inexpensive and reliable interface device that permits the microcomputer to accept inputs from a wide variety of manipulanda and permit activation of toys and other consequences.

The microcomputer accepted two independent inputs and controlled six independent outputs. Outputs were switch closures which operated battery-powered toys and a 110-volt relay, which operated additional consequences. At each site equipment was set up in a room separate from the classrooms. This was done primarily to limit the amount of noise and disruption that the sessions would have produced for the classroom, particularly in the beginning when it was necessary to experiment with strategies for positioning and response shaping.

Software

Software developed for this project by Richard Harkins allowed the microcomputer to record child responses to disk and to produce consequences. This program provided continuous reinforcement for one switch; it also provided a two-switch discrimination task. Finally, this program also generated graphs of individual sessions as needed. Its author gives permission for the unrestricted use and duplication of this program for noncommercial purposes. Listings of these programs are included in Appendix A.

Procedures and Findings

Initial experience with two-switch task. All children were initially presented with two switches only one of which produced a consequence. If the child did not attempt to activate a switch, a progression from verbal prompts to physical guidance was used in an effort to initiate the desired performance. This procedure involved a sequence of prompts progressing from: (1) verbal prompting, followed by (2) demonstration, (3) physical prompting, and (4) physical guidance. Generally, this sequence did not produce adequate levels of child performance. Two major problems were associated with these procedures. First, children who might have readily acquired the task appeared to be confused by the two switches and discouraged by the inconsistent results that the two switches produced. Second, the use of prompts and physical guidance was not effective in encouraging independent child performance. High levels of prompting and guiding children by teaching staff were recorded. While these procedures were in place, up to 100% of the consequences some children received were the result of staffs' physical prompts and/or guidance of child

actions. It is our impression that staff reliance on verbal and physical prompting encouraged pupils to wait until the consequences were activated for them.

Modification of procedures. These procedures were then modified so that (1) only children whose performance was unimpeded by the presence of two switches continued with two switches, all others were provided only one switch; and (2) physical prompts and physical guidance were eliminated. A shaping procedure of reinforcement of gradual approximations was instituted in place of guiding and prompting.

Single-switch task. Sessions were 10 minutes in length for all but 1 of the 26 pupils. Five-minute sessions were used with a pupil who consistently became upset during the 10-minute sessions. This pupil's performance never reached criterion. Pupils were presented with a single-switch which provided continuous reinforcement. Consequences consisted of the activation of toys, taped music, or colored lights for a brief period. The duration of the consequences ranged from 5 to 14 seconds, depending on the requirements of training and the nature of the consequences. Activation of a switch produced the consequences. Depression of the switch while the consequence was on had no effect on the consequences. The switch activation produced an additional consequence only when the consequences were off. Children were classified as having successfully acquired the single lever pressing task if they had demonstrated the ability to operate the switches without assistance for three consecutive sessions and for each of the three sessions had responded at an average rate of greater than one response per minute.

Of the 26 subjects, 18 met the criteria for successful acquisition of the single switch task. Pupils who mastered this task required an average of 6 sessions to reach criterion performance. A considerable range in number of sessions to acquisition was observed, ranging from a minimum of acquisition in the initial session to a maximum of 21 sessions (SD = 6). For pupils who successfully learned the single-switch task, the relationship of their sensorimotor level to their rate of acquisition was examined. A Pearson correlation between sensorimotor level and the number of sessions to reach criteria was found to be -.61 ($N = 17$, $p = .005$). This result indicates that pupils having higher levels of sensorimotor abilities learned the single-switch task more rapidly than pupils functioning at lower sensorimotor levels.

Pupils' performance was also analyzed to assess the relationship between their pattern of lever pressing and their level of sensorimotor functioning. The pattern of switch use differed for children having different levels of sensorimotor abilities. More sophisticated pupils used the switches to produce displays in a more selective manner than did pupils functioning at lower cognitive levels. Figures 1 through 4 provide examples of more and of less selective styles of switch use. Figures 1 and 2 depict highly selective use of single switches to produce consequences. The performance of D., aged 6 and who is estimated to be functioning at sensorimotor level 5, is depicted in Figure 1. Figure 2 depicts the performance of T. aged 11 whose cognitive abilities were above the sensorimotor level. Figure 3 is an example of switch use by R., aged 5, whose sensorimotor functioning was estimated to be stage 3. Figure 4 depicts responding by C.,

Figure 1
Single Switch Performance

STUDENT D.

DATE/TIME

TEST DURATION: 10 MINUTES

38 CLOSURES OF SWITCH #1
20 REINFORCEMENTS FOR #1
0 CLOSURES OF SWITCH #2
0 REINFORCEMENTS FOR #2

#1 CLOSED FOR 12.7 SECONDS
#2 CLOSED FOR 0 SECONDS

#1 REINFORCED FOR 199 SECONDS
#2 REINFORCED FOR 0 SECONDS

100 % OF TOTAL RESPONSES TO #1
0 % OF TOTAL RESPONSES TO #2

53 % OF RESPONSES TO #1 REINFORCED
0 % OF RESPONSES TO #2 REINFORCED

REINFORCEMENT DURATION FOR #1: 10 SECONDS
REINFORCEMENT DURATION FOR #2: 0 SECONDS

RELAY(S) ACTIVATED BY #1: 6
RELAY(S) ACTIVATED BY #2: NONE

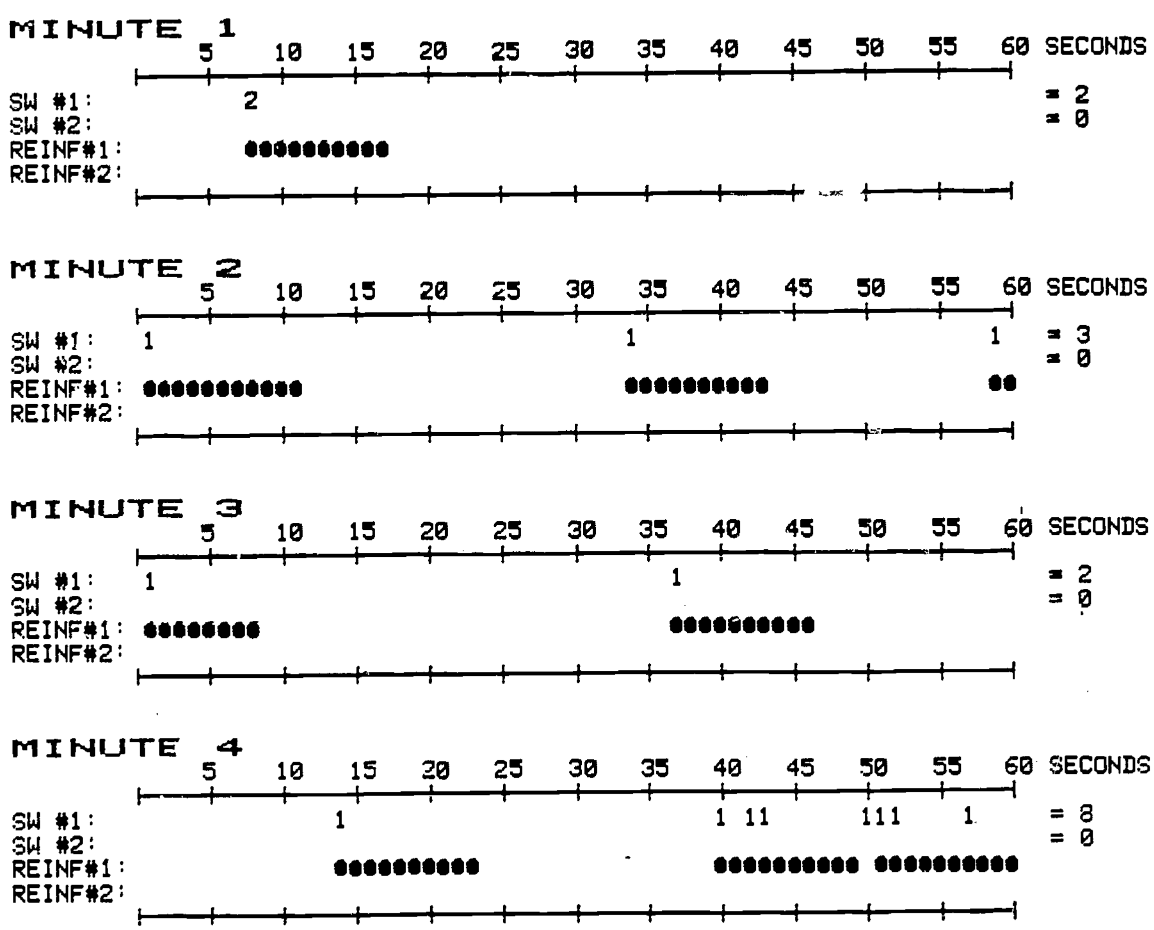

Figure 2
Single Switch Performance

STUDENT T.
DATE/TIME

TEST DURATION: 10 MINUTES

68 CLOSURES OF SWITCH #1
32 REINFORCEMENTS FOR #1
0 CLOSURES OF SWITCH #2
0 REINFORCEMENTS FOR #2

#1 CLOSED FOR 256.8 SECONDS
#2 CLOSED FOR 0 SECONDS

#1 REINFORCED FOR 317 SECONDS
#2 REINFORCED FOR 0 SECONDS

100 % OF TOTAL RESPONSES TO #1
0 % OF TOTAL RESPONSES TO #2

47 % OF RESPONSES TO #1 REINFORCED
0 % OF RESPONSES TO #2 REINFORCED

REINFORCEMENT DURATION FOR #1: 10 SECONDS
REINFORCEMENT DURATION FOR #2: 0 SECONDS

RELAY(S) ACTIVATED BY #1: 6
RELAY(S) ACTIVATED BY #2: NONE

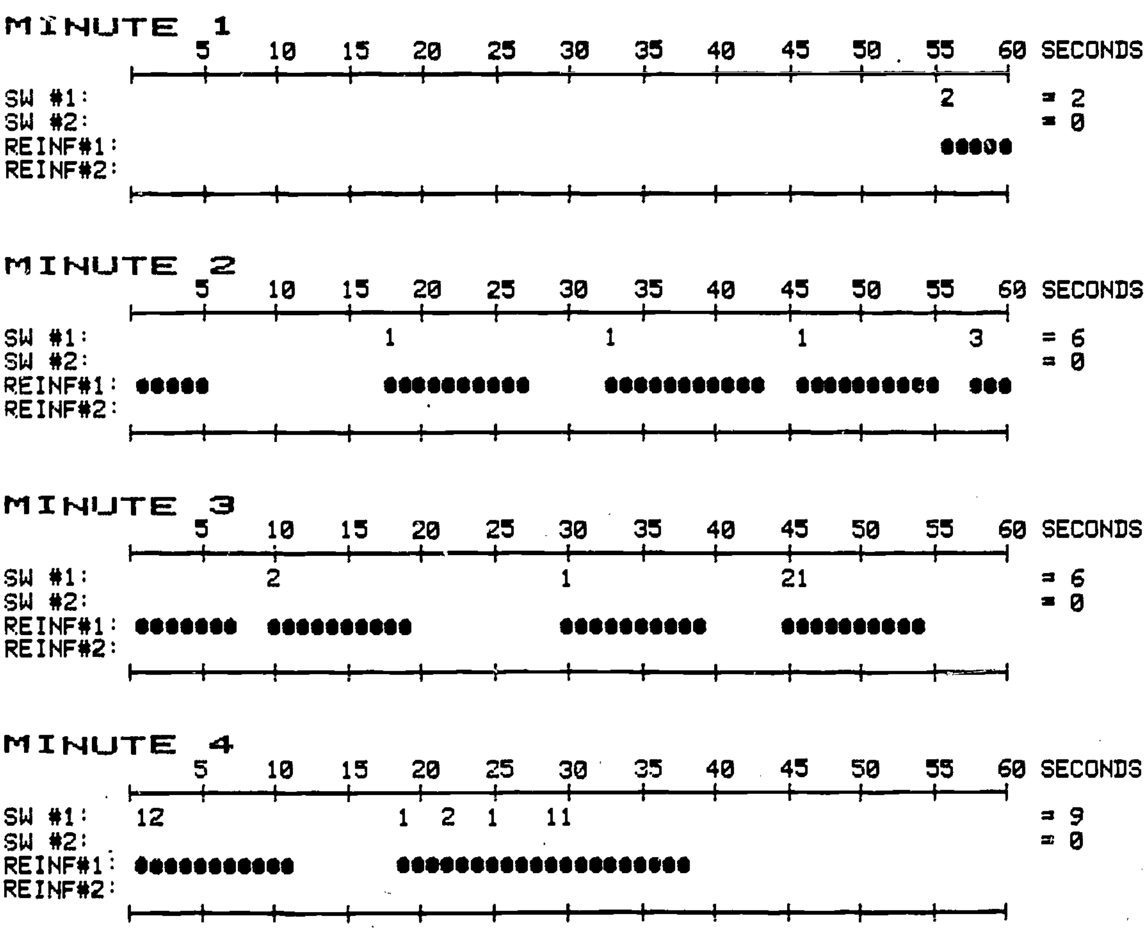

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Figure 3
Single Switch Performance

STUDENT R.

DATE/TIME

TEST DURATION: 10 MINUTES

647 CLOSURES OF SWITCH #1
32 REINFORCEMENTS FOR #1
0 CLOSURES OF SWITCH #2
0 REINFORCEMENTS FOR #2

#1 CLOSED FOR 156.4 SECONDS
#2 CLOSED FOR 0 SECONDS

#1 REINFORCED FOR 469 SECONDS
#2 REINFORCED FOR 0 SECONDS

100 % OF TOTAL RESPONSES TO #1
0 % OF TOTAL RESPONSES TO #2

5 % OF RESPONSES TO #1 REINFORCED
0 % OF RESPONSES TO #2 REINFORCED

REINFORCEMENT DURATION FOR #1: 15 SECONDS
REINFORCEMENT DURATION FOR #2: 0 SECONDS

RELAY(S) ACTIVATED BY #1: 6
RELAY(S) ACTIVATED BY #2: NONE

```
MINUTE 1
           5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|
SW #1:                                                                          = 0
SW #2:                                                                          = 0
REINF#1:
REINF#2:
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|

MINUTE 2
           5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|
SW #1:                             1           3  5 2212252221[illegible]       = 50
SW #2:                                                                          = 0
REINF#1:                           ●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●
REINF#2:
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|

MINUTE 3
           5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|
SW #1:    22214 21222 231412323262 44213222111241112  2 23    3 1121   1        = 100
SW #2:                                                                          = 0
REINF#1:  ●●●●●●●●● ●●●●●●●●●●●●●●● ●●●●●●●●●●●●●●●●  ●●●●●●●●●●●●●●●● ●
REINF#2:
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|

MINUTE 4
           5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|
SW #1:     3 1          1   111 312    3 3331  211 13222 2232 1 36112           = 64
SW #2:                                                                          = 0
REINF#1:  ●●●●●●●●●●●●●●   ●●●●●●●●●●●●●●● ●●●●●●●●●●●●●●●●●●●●●●●●●●
REINF#2:
         |----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----|
```

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Figure 4
Single Switch Performance

STUDENT C.

DATE/TIME

TEST DURATION: 10 MINUTES

191 CLOSURES OF SWITCH #1
46 REINFORCEMENTS FOR #1
0 CLOSURES OF SWITCH #2
0 REINFORCEMENTS FOR #2

#1 CLOSED FOR 91 SECONDS
#2 CLOSED FOR 0 SECONDS

#1 REINFORCED FOR 233 SECONDS
#2 REINFORCED FOR 0 SECONDS

100 % OF TOTAL RESPONSES TO #1
0 % OF TOTAL RESPONSES TO #2

24 % OF RESPONSES TO #1 REINFORCED
0 % OF RESPONSES TO #2 REINFORCED

REINFORCEMENT DURATION FOR #1: 5 SECONDS
REINFORCEMENT DURATION FOR #2: 0 SECONDS

RELAY(S) ACTIVATED BY #1: 1 6
RELAY(S) ACTIVATED BY #2: NONE

MINUTE 1

```
               5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
          |----+----+----+----+----+----+----+----+----+----+----+----|
SW #1:                                 1      122 2 2    1 212 2  11       = 20
SW #2:                                                                     = 0
REINF#1:                               ●●●●● ●●●●● ●●●●●  ●●●●●  ●●●●
REINF#2:
          |----+----+----+----+----+----+----+----+----+----+----+----|
```

MINUTE 2

```
               5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
          |----+----+----+----+----+----+----+----+----+----+----+----|
SW #1:     1 11  2          1 211 11 222  1  1      1  12222222 2 22 2     = 44
SW #2:                                                                     = 0
REINF#1:   ● ●●●●●          ●●●●● ●●●●●●  ●●●●●     ●●●●● ●●●●● ●●●●●
REINF#2:
          |----+----+----+----+----+----+----+----+----+----+----+----|
```

MINUTE 3

```
               5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
          |----+----+----+----+----+----+----+----+----+----+----+----|
SW #1:       21111  2 211 11111 2    1 2111    12 1    2 222 112     2 2   = 45
SW #2:                                                                     = 0
REINF#1:     ●●●●●  ●●●●● ●●●●● ●●●●●  ●●●●●   ●●●●●   ●●●●● ●●●●●  ●●●
REINF#2:
          |----+----+----+----+----+----+----+----+----+----+----+----|
```

MINUTE 4

```
               5    10    15    20    25    30    35    40    45    50    55    60 SECONDS
          |----+----+----+----+----+----+----+----+----+----+----+----|
SW #1:     2    211   1 1 12        1     1  1     2 1       1 1   1211    = 24
SW #2:                                                                     = 0
REINF#1:   ●●   ●●●●● ●●●●●●●●●●●   ●●●●●●●●●●●    ●●●●●     ●●●●● ●●●●●
REINF#2:
          |----+----+----+----+----+----+----+----+----+----+----+----|
```

aged 9, whose sensorimotor level was between 2 and 3. These figures indicate the more selective use of the switch by D. and T. than by R. and C.

The pattern of lever pressing was quantified using the ratio of lever presses to consequences. For all pupils who reached criterion performance, the ratios of lever presses to consequences for the last two of the three criterion sessions were averaged. A Pearson correlation of pupil sensorimotor level and average ratio was calculated to be -.32 (N = 17, p = .10), suggesting a developmental trend in pupils' patterns of lever pressing for the single switch task. Apparently pupils who have a more sophisticated understanding of causal relationships may use the switches more selectively than children functioning at lower sensorimotor levels.

Two-switch discrimination task. Pupils mastering the single switch activity were provided with a two-switch discrimination task. Of the 17 pupils who mastered the single-switch task, 3 also mastered the discrimination task. In this problem only one of the two switches was consequated. The consequated switch provided continuous reinforcement during the period that the consequence was off. All consequences lasted for 10 seconds. When at least 80% of a pupil's responses were directed at the consequated switch for two consecutive sessions, this switch was deactivated and the other switch consequated from the beginning of the next session.

Two pupils also learned to discriminate consequated and non-consequated switches. Graphs of their performance can be found in Figures 5 and 6.

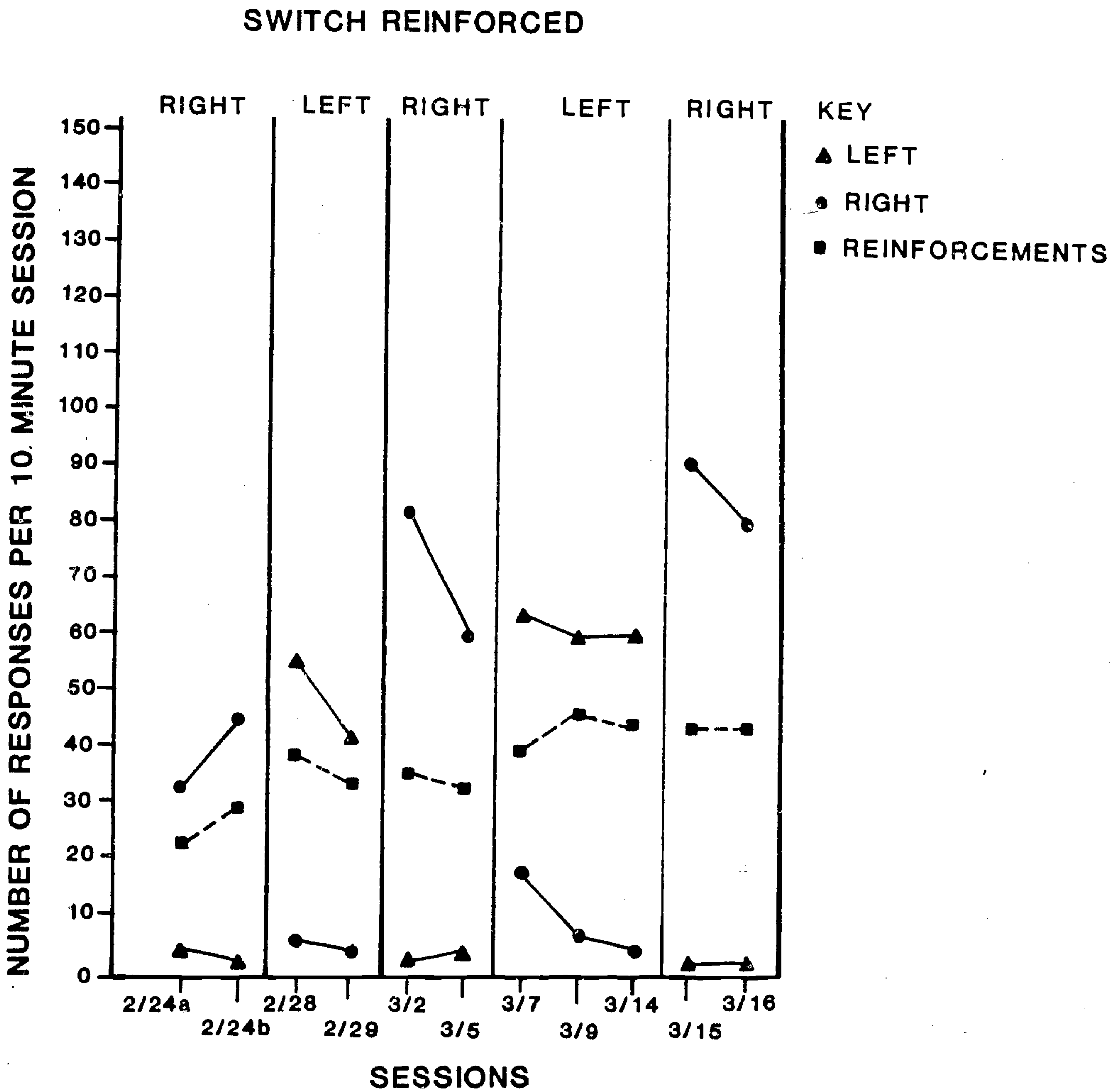

Figure 5. Switch program data for T.

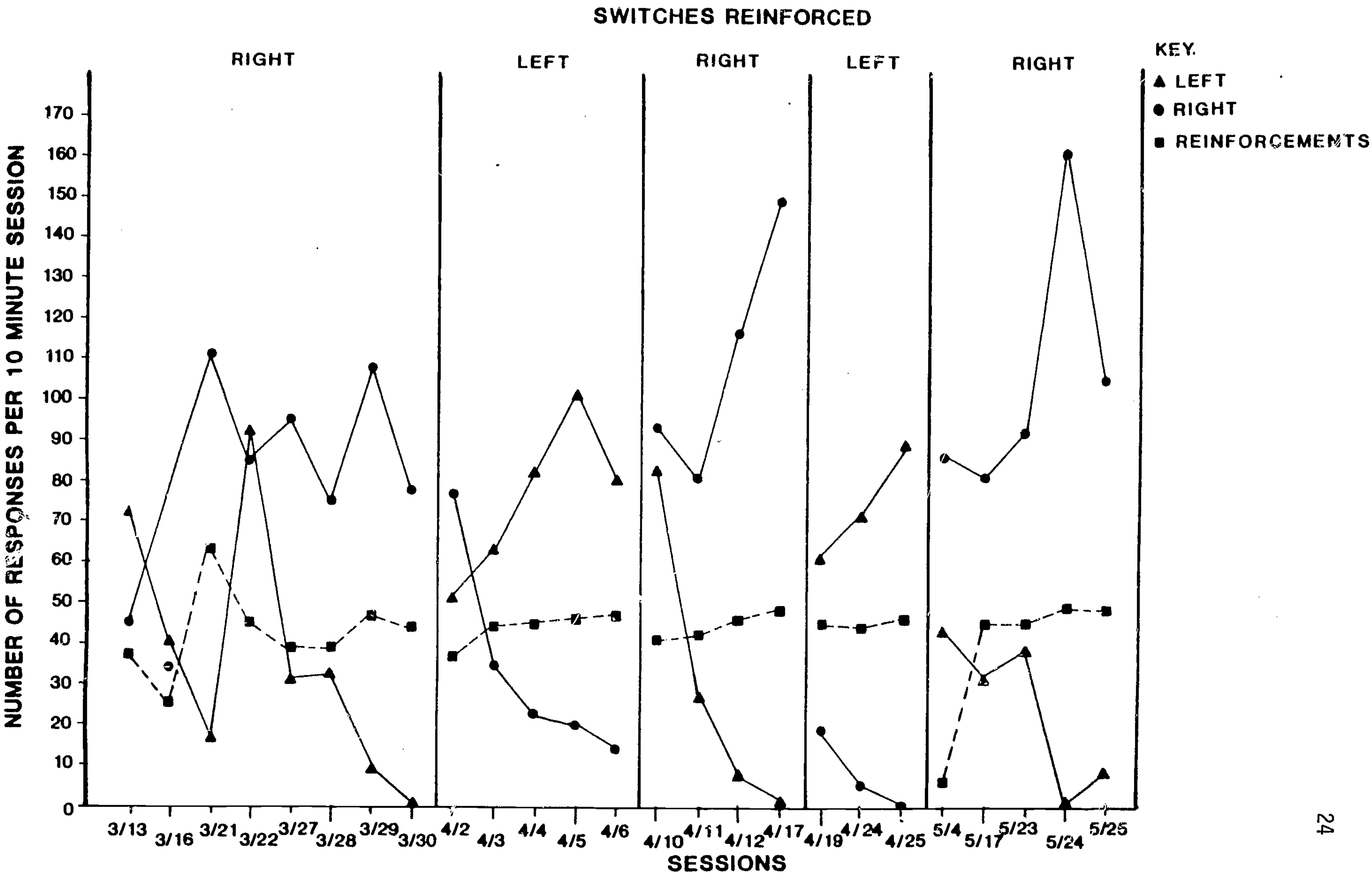

Figure 6. Switch program for D.

24

T., a legally blind and motorically handicapped boy of 11 years, is non-verbal and non-ambulatory. He was found to be out of the sensorimotor period. T. is estimated to have a cognitive age of between 2 and 3 years.

Figure 5 illustrates T.'s performance on the discrimination task. Despite his physical and sensory handicaps, T. has cerebral palsy and only functional vision, he rapidly demonstrated an ability to distinguish the switch that produced a consequence from the switch that did not. Responses to the switch placed on the left side of T.'s tray are indicated by the triangle; responses to the right switch are indicated by the circle. The square indicates the number of times the reinforcing event was activated during each session. These data indicate that he could reliably differentiate the consequated from the non-consequated switch.

D. is a six-year-old boy with a diagnosis of cerebral palsy, severe mental retardation, communication delay, visual impairment, and seizure disorder. He is semi-ambulatory, and can only vocalize non-speech and speech sounds. He has been assessed as performing in sensorimotor stage 5.

Figure 6 illustrates D.'s performance. The same symbols are used in this graph as in Figure 5. D. readily differentiated the consequated and non-consequated switch, and overall showed an excellent rate of responding.

Communication task. The use of the workstation to provide non-verbal children with a means of signalling staff members in order to obtain adult attention was to be evaluated as part of this study.

Because only one child mastered the task, no formal analysis of the data will be presented in this report.

Subjects entered this study after successfully completing the discrimination task. Only one child (T.) mastered this task early enough in the study to be presented with the signalling task.

The workstation and tape recorder provided a taped message, "Pat, this is T. Come here I want you.", which requested T.'s teacher's attention. The teacher then presented T. a choice of two objects, of which he chose one to play with. After one minute the toy was removed and T. was again required to use the switch to produce the message requesting his teacher's attention. This procedure was repeated for a 10-minute period. T. mastered this task during the initial 10-minute session.

Delayed consequences task. This task was not implemented. This portion of the study was to have followed the discrimination task. However, the greater than anticipated duration of the single-switch and two-switch phases of this study did not leave time in which the delayed consequences task could be evaluated.

Manual Development

A manual to guide teachers in the use of the workstation and associated software is under development.

DISCUSSION

There were two central findings in this research. First, 18 of the 26 pupils who participated in this study learned to use a switch to produce interesting consequences. Of these 18, 3 pupils also

learned to distinguish between two switches in order to reliably use the switch which produced consequences.

The second finding is the possible relationship between the pattern of switch use that children display and their cognitive level. In this work we found a modest tendency for pupils to operate the switches increasing selectivity as their level of sensorimotor functioning increased.

Several secondary objectives had to be accomplished in order to work successfully with these pupils. A microcomputer and associated equipment had to be selected and software developed to run the microcomputer. The pupils had to be provided with access to switches that they could reliably use. This required considerable care in selecting switches and in positioning the switches and the pupils. Finally, the pupils had to be shaped to the use of the switches--the use of prompting and physical guidance proved, in this work, to be unsatisfactory as training strategies.

The children who had severe motor disorders probably enjoyed and benefited most from participation in this project. By and large, these children persisted and appeared interested in these activities over long periods of time, far longer than would be typical of nonhandicapped infants and toddlers having comparable intellectual abilities. What the motorically handicapped children received was an opportunity to act directly on the world, to cause events by their own actions rather than through another person.

Overall, the mentally retarded, but motorically unimpaired children seemed less persistent and less enthusiastic than their motorically handicapped counterparts. At this point, it is our impression that, for individuals functioning within the sensorimotor

period, motivation depends largely on whether the apparatus permits them to do something they could not do before. The novelty wears off for individuals whose hands and legs permit them to interact with their environment at will. In contrast, pupils who have severely limited motor skills need assistance in order to have this interaction. Consequently, motorically handicapped pupils appeared to be more highly motivated to use the switches to produce displays. It is not surprising that pupils who have the ability to move from activity to activity at will may find sitting with a switch that produces a limited variety of consequences restrictive and, as a result, rather aversive. Additional work needs to be done to determine which groups of handicapped pupils are best served with technology that offers them environmental controls through the use of simple lever pressing arrangements.

The desire to act on one's environment is an important characteristic of these, and all other, pupils. To a large extent, it is this motivation that makes education possible. The striking persistence of many of the pupils with whom we worked is similar to the persistence displayed by other primates who are placed in extremely deprived environments--environments that lack opportunities to participate in changing events (Butler & Alexander, 1955). These animals showed enormous persistence on simple tasks, apparently because these tasks broke the monotony of their existences. Pupils who have severe motor disorders are also deprived of opportunities to act on their environments. They, like Butler's monkeys, tend to persist at the few activities available to them in order to relieve the monotony of their existence. This work has shown something of

what these pupils can do if given the opportunity. It is essential that additional activities be provided them; activities that are developmentally appropriate and functionally relevant.

Such adaptation of interesting activities so as to make them physically possible represents a major challenge for workers. Microcomputer technology can be very helpful by permitting flexible arrangements of consequences and child responses. The major problems, however, are the creation of meaningful activities, activities that lead to more advanced and adaptive skills. This challenge is greatest for the development of activities for pupils whose cognitive abilities fall between 1 and 3 years of age--for these pupils are probably insufficiently stimulated by the simple lever pressing arrangements used in this work but are not yet capable of utilizing the more sophisticated activities that are available through even the least complex communication software presently available.

Our findings regarding the relationship between sensorimotor level and task performance, increased facility in acquisition with higher sensorimotor levels, suggests a promising direction for assessment strategies for severely physically disabled individuals functioning at less than 2 years developmentally. Currently, there are no adequate tools for assessing cognitive level with such pupils. Sensorimotor scales (Uzgiris & Hunt, 1975) have been advocated as an alternative. However, the flexibility offered within the sensorimotor scales is not sufficient in and of itself for accurate assessment of the most physically disabled students. Another limitation in use of the sensorimotor scales and any other assessment tool is the level, skill, and experience required of the clinician performing the

assessment. If performance on the switch task can be further demonstrated to correspond highly with assessed sensorimotor level, the switch-type task with interpretation of the pattern of performance within the sensorimotor framework would offer a valuable form of preliminary assessment, and which would not require highly trained clinicians.

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Dissemination

Presentations

Rosenberg, S., & Valentic, D. (1983, October). _Adapting toys._ Paper presented at the Annual Region VIII AAMD Conference, Des Moines, IA.

Robinson, C., & Rosenberg, S. (1983, October). _A microcomputer workstation for the severely/profoundly handicapped_. Paper presented at the Nebraska Council for Exceptional Children Annual Conference, Omaha, NE.

Rosenberg, S., & Robinson, C. (1984, October). _A microcomputer workstation for severely handicapped children_. Paper presented at the Annual Meeting of the American Academy for Cerebral Palsy and Developmental Medicine, Washington, DC.

Rosenberg, S., Harkins, R., & Robinson, C. (1984, October). _A microcomputer workstation for severely handicapped children_. Paper presented at the Third International Conference on Augmentative and Alternative Communication, Cambridge, MA.

Rosenberg, S., & Robinson, C. (1984, November). ACTT Symposium on Microcomputer Applications for Young Handicapped Children, Western Illinois University, Macomb, IL.

Rosenberg, S., & Robinson, C. (1985, April). _Switch activities for severely multiply handicapped pupils_. Paper presented at the Conference on Use of the Microcomputer with the Nonreading Communicatively Handicapped, Omaha, NE.

Rosenberg, S., & Robinson, C. (1985, May). Microcomputer-generated activities for pupils with severe handicaps. Paper presented at the annual meeting of the American Association on Mental Deficiency, Philadelphia, PA.

Appendix A

Software

This program provides activities for the workstation.

```
5 PRINT"{SC}"TAB(14)"INITIALIZING"
10 REMCOPYRIGHT 1983 - A/SYSTEMS, OMAHA, NEBR
15 DDR=56579:DR=56577:POKEDDR,63:POKEDR,0:RT$=CHR$(13)
16 DIM SA%(1800):DIM RA%(1800):SA%(1800)=0:RA%(1800)=0
18 TI$="000000":T=0:TC=0:CL=0:CR=0:C1=0:C2=0:S1=0:S2=0
19 D1%=0:D2%=0:T1=0:T2=0:SF=0:O1=0:O2=0
20 PRINT"{SC}":PRINT:PRINT:PRINT"DISCRIMINATED OPERANT TASK - VERSION 2.1"
21 PRINTTAB(11)"FOR COMMODORE '64'":FORB=1TO 17:PRINT:NEXT
30 PRINT"   (C) 1983 - A/SYSTEMS, OMAHA, NEBR":FORB=1TO1500:NEXTB
50 DATA FIRST,SECOND,THIRD,FOURTH,FIFTH,SIXTH
55 FOR B=1TO6:READB$:NEXT:REM DUMMY TO GET PAST TEXT DATA ITEMS
90 IFPEEK(788)=10THENGOTO300:REM IRQ ROUTINE ALREADY INSTALLED?
108 REM ******BEGIN IRQ ROUTINE ******
110 DATA173,01,221,170,41,64,205,0,192,240,10,201,0
112 DATA208,3,238,2,192,141,0,192,201,64
120 DATA240,30,24,169,1,109,4,192,141,4,192,144
122 DATA19,24,169,1,109,5,192,141,5,192,144,8,169,1
130 DATA109,6,192,141,6,192,138,41,128,205,1,192,240
132 DATA 10,201,0,208,3,238,3,192,141,1,192,201
140 DATA128,240,30,24,169,1,109,7,192,141,7,192,144
142 DATA19,24,169,1,109,8,192,141,8,192,144,8
150 DATA169,1,109,9,192,141,9,192,76,49,234
155 REM ******END OF IRQ ROUTINE******
156 REM ******BEGIN INSTALL RTN ******
160 DATA 120,169,10,141,20,3,169,192,141,21,3,88,96
165 REM ******END OF INSTALL RTN******
200 FORB=0TO122
210 READ W:POKE(49162+B),W:NEXT
235 SYS49272:REM DO IRQ INSTALL ROUTINE
300 S=10:PRINT"{SC}DURATION OF TEST IN MINUTES(10)":INPUTS:S=S*3600
305 QW$="WHAT???"
```

```
310 IFS<0ORS>108000THENPRINTQW$:FORB=1TO1000:NEXTB:GOTO300
350 PRINT"ACTIVATE HOW MANY RELAYS IN RESPONSE TO SWITCH #1? 0 TO 6 (1)"
355 R1%=0:W=1:INPUTW:IFW<0ORW>6THENPRINTQW$:GOTO350
360 IF W=0THEN GOTO 370
362 RESTORE:FOR B=1TOW:READB$
363 PRINT"ENTER "B$" RELAY #":INPUTR1:IFR1<1ORR1>6THENPRINTQW$:GOTO363
365 R1%=R1%OR2^(R1-1):NEXT
370 PRINT"ACTIVATE HOW MANY RELAYS IN RESPONSE TO SWITCH #2? 0 TO 6 (0)"
375 R2%=0:W=0:INPUTW:IFW<0ORW>6THENPRINTQW$:GOTO370
380 IF W=0THEN GOTO 400
382 RESTORE:FOR B=1TOW:READB$
383 PRINT"ENTER "B$" RELAY #":INPUTR1:IFR1<1ORR1>6THENPRINTQW$:GOTO383
385 R2%=R2%OR2^(R1-1):NEXT
390 IF(R1%ANDR2%)=0THEN400
391 PRINT"WARNING - SAME RELAY ACTIVATED BY BOTH  SWITCHES! CONTINUE? (Y/N)"
392 INPUT B$:IFB$="Y"THENGOTO400
393 PRINT"{SC}":GOTO 350
400 IFR1%=0THEN430
410 PRINT"REINFORCEMENT DURATION FOR #1 IN SECONDS(10)
420 D1=10:INPUTD1:D1=D1*60:IFD1<0ORD1>STHENPRINTQW$:GOTO400
430 IFR2%=0THEN460
440 PRINT"REINFORCEMENT DURATION FOR{CR}#2 IN SECONDS(10)
450 D2=10:INPUTD2:D2=D2*60:IFD2<0ORD1>STHENPRINTQW$:GOTO420
460 XS=0:PRINT"EXCLUSIVE SWITCH-0,1,2(0)":INPUTXS
470 IFXS<0ORXS>2THENPRINTQW$:GOTO460
500 PRINT:PRINT:PRINTTAB(9)"{RV}PRESS ANY KEY TO START"
510 GETB$:IFB$=""THEN510
600 D1%=0:D2%=0:T1=0:T2=0:SF=0:O1=0:O2=0:T=60:TC=0:CL=0:CR=0:C1=0:C2=0:S1=0:S2=
610 POKE49152,64:POKE49153,128:FORB=0TO7:POKE(49154+B),0:NEXT
615 POKEDDR,63:POKEDR,0:TI$="000000"
620 PRINT"{SC}"
630 PRINT"     CLOSURES OF SWITCH #1"
640 PRINT"     REINFORCEMENTS FOR #1"
```

```
650 PRINT"      CLOSURES OF SWITCH #2"
660 PRINT"      REINFORCEMENTS FOR #2"
670 F1$="F1 - RESTART":F3$="F3 - NEW TEST"
680 PRINT:PRINTF1$:PRINTF3$
700 IF TI>TTHENGOSUB1000
710 IFTI>STHEN9000
720 PL%=PEEK(49154):PR%=PEEK(49155)
730 IFPL%>0THENGOSUB2000
735 IFPR%>0THENGOSUB2500
740 IFD1%=1THENIFTI>S1THENPOKEDR,PEEK(DR)AND63-R1%:D1%=0
750 IFD2%=1THENIFTI>S2THENPOKEDR,PEEK(DR)AND63-R2%:D2%=0
760 GETB$:IFB$=CHR$(133)THEN600
770 IFB$=CHR$(134)THEN300
790 GOTO700
1000 REM CLOCK TICK ROUTINE
1010 TC=TC+1:T=(TC+1)*60:T1=T1+D1%:T2=T2+D2%
1020 PRINT"{HM}";MID$(TI$,3,2);":";RIGHT$(TI$,2);RT$;CL;RT$;C1;RT$;CR;RT$;C2
1030 SA%(TC-1)=CL-O1+((CR-O2)*16):O1=CL:O2=CR:RA%(TC-1)=D1%+16*D2%
1090 RETURN
2000 CL=CL+PL%:POKE49154,(PEEK(49154)-PL%)
2010 IFR1%=0THEN2090
2015 IFXS=2ANDPEEK(49153)=0THEN2090
2020 IFD1%=0THENPOKEDR,PEEK(DR)ORR1%:S1=TI+D1:D1%=1:C1=C1+1
2090 RETURN
2500 CR=CR+PR%:POKE49155,(PEEK(49155)-PR%)
2510 IFR2%=0THEN2590
2515 IFXS=1ANDPEEK(49152)=0THEN2590
2520 IFD2%=0THENPOKEDR,PEEK(DR)ORR2%:S2=TI+D2:D2%=1:C2=C2+1
2590 RETURN
9000 POKEDR,0:FORB=1264TO1344:POKEB,32:NEXT
9005 PRINT"{HM}";MID$(TI$,3,2);":";RIGHT$(TI$,2);RT$;CL;RT$;C1;RT$;CR;RT$;C2
9010 SA%(TC)=-1:RA%(TC)=-1
9020 B=(PEEK(49156)+256*PEEK(49157)+65536*PEEK(49158))/60
```

```
9025 PRINT:PRINT "#1 CLOSED FOR";INT(B*10)/10;"SECONDS"
9030 B=(PEEK(49159)+256*PEEK(49160)+65536*PEEK(49161))/60
9035 PRINT"#2 CLOSED FOR";INT(B*10)/10;"SECONDS"
9050 PRINT:PRINT"#1 REINFORCED FOR";T1;"SECONDS"
9060 PRINT"#2 REINFORCED FOR";T2;"SECONDS"
9070 IF CL+CR=0THEN9500
9080 PRINT:PRINTINT((CL/(CL+CR))*100+.5);"% OF TOTAL RESPONSES TO #1"
9090 PRINTINT((CR/(CL+CR))*100+.5);"% OF TOTAL RESPONSES TO #2"
9100 PRINT:IFCL<>0THENPRINTINT((C1/CL)*100+.5);
9102 IFCL=0THENPRINT" 0 ";
9105 PRINT"% OF RESPONSES TO #1 REINFORCED"
9110 IFCR<>0THENPRINTINT((C2/CR)*100+.5);
9112 IFCR=0THENPRINT" 0 ";
9115 PRINT"% OF RESPONSES TO #2 REINFORCED"
9500 PRINT:PRINTF1$:PRINT"F2 - STORE TEST DATA TO DISC":PRINTF3$
9503 PRINT"F5 - PRINT SUMMARY":PRINT"F7 - PRINT DETAIL"
9510 GETB$:IFB$=CHR$(133)THEN600
9520 IFB$=CHR$(134)THEN300
9530 IFB$=CHR$(135)THENRS=1:RF=16:OPEN4,4:GOSUB20000:CLOSE4
9540 IF B$=CHR$(136)THENOPEN4,4:GOSUB40000:CLOSE4
9550 IFB$=CHR$(137)THENGOSUB30000:GOTO9500
9560 GOTO 9510
20000 REM PRINT SCREEN TO PRINTER
20100 REM RS= ROW TO START ON, RF=ROW TO FINISH ON
20200 IFCL+CR=0THENRF=10
20300 VR=PEEK(648)*256
20500 FORRO=RSTORF:AS$="":FORCO=0TO39
20600 SC=PEEK(VR+(40*RO)+CO)
20700 IFSC<32THENSC=SC+64:GOTO21600
21600 AS$=AS$+CHR$(SC)
21800 NEXTCO
22000 PRINT#4,AS$
22100 NEXTRO
```

```
22200 RETURN
30000 REM STORE ARRAYS TO DISC:R$=CHR$(13)
30005 IF SF=1THENPOKE214,PEEK(214)-1:PRINT"TEST ALREADY STORED":GOTO30510
30010 SF=1:REM DON'T ALLOW ANYONE TO SAVE THE SAME TEST MORE THAN ONCE
30020 PRINT"{CU}{CU}{CU}{CU}{CU}{CU}":REM MOVE CURSOR UP
30025 T=PEEK(214)
30030 W=((T-1)*40)+1024:REM WHERE IS CURSOR?
30040 FOR B=W TO W+320:POKEB,32:NEXT
30050 PRINT"FIRST NAME";
30060 INPUT N1$
30080 PRINT"LAST NAME";
30090 INPUT N2$
30110 PRINT"TODAY'S DATE (MM/DD/YY)";
30120 INPUT DT$
30130 INPUT"WAS EVERYTHING ENTERED OK? (Y/N)";B$
30140 IF B$<>"Y"THEN POKE214,T-1:PRINT "OK - TRY AGAIN":GOTO 30040
30400 POKE214,T-1:FORB=WTOW+320:POKEB,32:NEXT
30405 PRINT"***":PRINT"INSERT DATA DISC THEN PRESS ANY KEY"
30407 GETB$:IFB$=""THEN30407
30408 PRINT"SAVING DATA - PLEASE WAIT....."
30410 OPEN15,8,15,"I"
30420 OPEN3,8,3,"@0:"+LEFT$(N1$,3)+LEFT$(N2$,3)+DT$+",S,W"
30430 INPUT#15,ER$,EN$,TR$,BL$:IFVAL(ER$)>19 THEN GOSUB36000:REM DISC PROB
30440 PRINT#3,S/3600:PRINT#3,R1%:PRINT#3,R2%:PRINT#3,D1/60:PRINT#3,D2/60
30443 PRINT#3,CL:PRINT#3,CR:PRINT#3,C1:PRINT#3,C2:PRINT#3,XS
30450 PRINT#3,T1:PRINT#3,T2
30455 PRINT#3,0:PRINT#3,0:PRINT#3,0:PRINT#3,0:REM 4 DUMMY BYTES FOR FUTURE
30460 FORTC=0 TO 1799
30480 PRINT#3,SA%(TC):PRINT#3,RA%(TC)
30485 IF SA%(TC)=-1THEN TC=1801
30490 NEXT TC
30500 INPUT#15,ER$,EN$,TR$,BL$:IFVAL(ER$)>19 THEN GOSUB36000:REM DISC PROB
30505 PRINT#3:CLOSE3:CLOSE15
```

```
30510 FOR B=W TO W+320:POKEB,32:NEXT
30520 POKE214,T-2:PRINT"DATA SAVED!"
30530 RETURN
36000 FOR B=W TO W+320:POKEB,32:NEXT
36010 POKE214,T-2:PRINT"DISC PROBLEM"
36020 PRINT ER$,EN$
36030 PRINT TR$,BL$
36040 RETURN
40000 REM PRINT DETAIL ROUTINE*********
40010 L1$="     5    10    15    20    25    30    35    40    45    50    55    60"
40020 L2$="©"
40030 SP$="        "
40040 PRINT#4,CHR$(14)+"STUDENT";
40050 PRINT#4,CHR$(15)+"":PRINT#4
40060 PRINT#4,CHR$(14)+"DATE/TIME";
40070 PRINT#4,CHR$(15)+"":PRINT#4
40080 PRINT#4,"TEST DURATION: "+STR$(S/3600)+" MINUTES":PRINT#4
40085 RS=1:RF=16:GOSUB20000:PRINT#4
40090 PRINT#4,"REINFORCEMENT DURATION FOR #1: "+STR$(D1/60)+" SECONDS"
40100 PRINT#4,"REINFORCEMENT DURATION FOR #2: "+STR$(D2/60)+" SECONDS":PRINT#4
40110 PRINT#4,"RELAY(S) ACTIVATED BY #1: ";
40112 FORB=0TO7:IF(R1%AND(2^B))>0THENPRINT#4,(B+1);
40113 NEXTB
40114 IFR1%=0THENPRINT#4,"NONE";
40115 PRINT#4
40120 PRINT#4,"RELAY(S) ACTIVATED BY #2: ";
40122 FORB=0TO7:IF(R2%AND(2^B))>0THENPRINT#4,(B+1);
40123 NEXTB
40124 IFR2%=0THENPRINT#4,"NONE";
40125 PRINT#4:PRINT#4:PRINT#4
40200 FORMC=0TO(S/3600)-1
40210 PRINT#4,CHR$(14)+"MINUTE"+STR$(MC+1)
40220 PRINT#4,CHR$(15)+SP$+L1$+" SECONDS"
```

```
40230 PRINT#4,SP$+L2$
40240 PRINT#4,"SW #1:   ";
40250 S1=0:FG=0
40260 FORPC=0TO59
40270 IFFG=0THENA%=SA%(PC+MC*60)
40280 IFA%=-1THENA%=0:FG=1
40290 A%=A%AND15:IFA%=0THENPRINT#4,"";:GOTO40400
40300 PRINT#4,RIGHT$((STR$(A%)),1);:S1=S1+A%
40400 NEXTPC
40410 PRINT#4,CHR$(16)+"71="+STR$(S1)
40420 PRINT#4,"SW #2:   ";
40430 S1=0:FG=0
40440 FORPC=0TO59
40450 IFFG=0THENA%=SA%(PC+MC*60)
40460 IFA%=-1THENFG=1:A%=0
40470 A%=(A%AND240)/16:IFA%=0THENPRINT#4," ";:GOTO 40500
40480 PRINT#4,RIGHT$((STR$(A%)),1);:S1=S1+A%
40500 NEXT PC
40510 PRINT#4,CHR$(16)+"71="+STR$(S1)
40520 FG=0
40530 PRINT#4,"REINF#1: ";
40540 FORPC=0TO59
40550 IFFG=0THENA%=RA%(PC+MC*60)
40560 IFA%=-1THENFG=1:A%=0
40570 A%=A%AND1:IFA%=0THENPRINT#4," ";:GOTO 40600
40580 PRINT#4,"";
40600 NEXTPC
40605 PRINT#4," "
40610 FG=0
40620 PRINT#4,"REINF#2: ";
40630 FORPC=0TO59
40640 IFFG=0THENA%=RA%(PC+MC*60)
40650 IFA%=-1THENFG=1:A%=0
```

```
40655 IFPC=0THENA%=1
40660 A%=A%AND16:IFA%=0THENPRINT#4," ";:GOTO 40700
40670 PRINT#4,"";
40700 NEXTPC
40800 PRINT#4," "
40810 PRINT#4,SP$+L2$:PRINT#4:PRINT#4
40900 NEXT MC
40910 RETURN

READY.
```

This program retrieves and prints graphs of sessions previously stored to disk.

```
10 REMCOPYRIGHT 1984 - A/SYSTEMS, OMAHA, NEBR
15 DDR=56579:DR=56577:POKEDDR,63:POKEDR,0:RT$=CHR$(13)
16 DIM SA%(1800):DIM RA%(1800):SA%(1800)=0:RA%(1800)=0
17 POKE54277,7:POKE54278,0:POKE54296,15:REM INITIALIZE SOUND CHIP
18 POKE 54272,177:POKE54273,25:POKE54276,33
20 PRINT"{SC}":PRINT:PRINT:PRINT"      DISCRIMINATED OPERANT TASK"
21 PRINT"  PRINT FROM DISK ROUTINE VERSION 1.0"
22 PRINTTAB(11)"DATE CODE 01/11/84":PRINT:PRINT
23 PRINTTAB(11)"FOR COMMODORE '64'":FORB=1TO 11:PRINT:NEXT
30 PRINT"   (C) 1984 - A/SYSTEMS, OMAHA, NEBR":FORB=1TO1500:NEXTB
1000 PRINT"{SC}THIS PROGRAM PRINTS TEST REPORTS FROM"
1010 PRINT"DATA THAT WAS PREVIOUSLY STORED TO A"
1020 PRINT"DISKETTE.  THE TEST DATA IS ACCESSED"
1030 PRINT"BY A 'FILE NAME'.  THIS NAME IS CREATED"
1040 PRINT"FROM THE FIRST THREE LETTERS OF THE
1050 PRINT"STUDENT'S FIRST NAME, THE FIRST THREE"
1060 PRINT"LETTERS OF THE LAST NAME, AND THE DATE"
1070 PRINT"THAT THE TEST WAS DONE(MM/DD/YY)"
1072 PRINT:PRINT:PRINT"EXAMPLE:":PRINT
1073 PRINT"    MIKSMI10/22/83   ":PRINT
1074 PRINT"WOULD BE MIKE SMITH'S TEST TAKEN ON"
1075 PRINT"OCTOBER 22ND, 1983":PRINT
1080 PRINT:PRINT"DO YOU WANT TO SEE A LIST OF ALL THE"
1090 PRINT"FILE NAMES ON YOUR DISKETTE?(Y/N)"
1100 INPUTB$
1110 IF B$="Y"THEN GOSUB50000:GOTO4000
1120 IF B$="N"THEN GOTO 4000
1130 PRINT:GOTO 1080
3999 GOSUB50000
4000 GOSUB 30000
```

```
5000 IF ER$<>"00"THEN GOTO 1000
8000 PRINT "{SC}";S/3600;" MINUTE TEST":PRINT
8010 PRINT"      CLOSURES OF SWITCH #1"
8020 PRINT"      REINFORCEMENTS FOR #1"
8030 PRINT"      CLOSURES OF SWITCH #2"
8040 PRINT"      REINFORCEMENTS FOR #2"
8050 PRINT"{HM}":PRINT
8060 PRINT CL:PRINTC1:PRINTCR:PRINTC2
9000 PRINT
9025 PRINT "#1 CLOSED FOR";N1;"SECONDS"
9035 PRINT"#2 CLOSED FOR";N2;"SECONDS"
9050 PRINT:PRINT"#1 REINFORCED FOR";T1;"SECONDS"
9060 PRINT"#2 REINFORCED FOR";T2;"SECONDS"
9070 IF CL+CR=0THEN9500
9080 PRINT:PRINTINT((CL/(CL+CR))*100+.5);"% OF TOTAL RESPONSES TO #1"
9090 PRINTINT((CR/(CL+CR))*100+.5);"% OF TOTAL RESPONSES TO #2"
9100 PRINT:IFCL<>0THENPRINTINT((C1/CL)*100+.5);
9102 IFCL=0THENPRINT" 0 ";
9105 PRINT"% OF RESPONSES TO #1 REINFORCED"
9110 IFCR<>0THENPRINTINT((C2/CR)*100+.5);
9112 IFCR=0THENPRINT" 0 ";
9115 PRINT"% OF RESPONSES TO #2 REINFORCED"
9500 PRINT:PRINT" {RV}F1{RO} - RESTART"
9510 PRINT" {RV}F5{RO} - PRINT SUMMARY"
9520 PRINT" {RV}F7{RO} - PRINT DETAIL"
9530 GET B$
9540 IF B$=CHR$(133)THEN GOTO1000
9550 IF B$=CHR$(135)THEN RS=0:RF=18:OPEN4,4:Z1=0:GOSUB20000:CLOSE4
9560 IF B$=CHR$(136)THEN OPEN4,4:Z1=1:GOSUB 40000:CLOSE4
9570 GOTO 9530
9999 STOP
20000 REM PRINT SCREEN TO PRINTER
20100 REM RS= ROW TO START ON, RF=ROW TO FINISH ON
```

```
20200 IFZ1=0THENPRINT "{RV}     PRINTING...PLEASE WAIT!     "
20300 VR=PEEK(648)*256
20500 FORRO=RSTORF:AS$="":FORCO=0TO39
20600 SC=PEEK(VR+(40*RO)+CO)
20700 IFSC<32THENSC=SC+64:GOTO21600
21600 AS$=AS$+CHR$(SC)
21800 NEXTCO
22000 PRINT#4,AS$
22100 NEXTRO
22101 IFZ1=1THENRETURN
22105 REM GIVE A 'BEEP' WHEN THE PRINTING IS DONE!
22125 IFZ1=0THENPOKE54276,32:POKE54276,33
22140 PRINT "{CU}{RO}                                        {CU}"
22200 RETURN
30000 REM LOAD ARRAYS FROM DISC:R$=CHR$(13)
30050 PRINT"ENTER THE STUDENT'S FIRST NAME";
30060 INPUT N1$
30080 PRINT"ENTER THE STUDENT'S LAST NAME";
30090 INPUTN2$
30110 PRINT"ENTER THE DATE OF THE TEST-"
30111 PRINT"(MM/DD/YY)";
30120 INPUT DT$
30130 PRINT:INPUT"WAS EVERYTHING ENTERED OK? (Y/N)";B$
30140 IF B$<>"Y"THEN PRINT"{SC}":PRINT "OK - TRY AGAIN":GOTO 30050
30150 PRINT:PRINT"{SC}{CD}{CD}{CD}READY TO ATTEMPT TO OPEN DATA FILE -"
30160 PRINT:PRINT"NAME OF FILE IS-  {RV}* ";
30170 PRINTLEFT$(N1$,3)+LEFT$(N2$,3)+DT$+" *{RO}"
30405 PRINT:PRINT"INSERT DATA DISC THEN PRESS ANY KEY"
30407 GETB$:IFB$=""THEN30407
30408 PRINT"{SC}LOADING DATA - PLEASE WAIT";
30410 OPEN15,8,15,"I"
30420 OPEN3,8,3,LEFT$(N1$,3)+LEFT$(N2$,3)+DT$+",S,R"
30430 INPUT#15,ER$,EN$,TR$,BL$:IFVAL(ER$)>19 THEN GOTO36000:REM DISC PROB
```

```
30440 INPUT#3,B$:S=3600*VAL(B$):INPUT#3,B$:R1%=VAL(B$):INPUT#3,B$:R2%=VAL(B$)
30441 INPUT#3,B$:D1=60*VAL(B$):INPUT#3,B$:D2=60*VAL(B$):PRINT".";
30443 INPUT#3,B$:CL=VAL(B$):INPUT#3,B$:CR=VAL(B$):INPUT#3,B$:C1=VAL(B$)
30444 INPUT#3,B$:C2=VAL(B$):INPUT#3,B$:XS=VAL(B$)
30450 INPUT#3,B$:T1=VAL(B$):INPUT#3,B$:T2=VAL(B$)
30453 INPUT#3,B$:N1=VAL(B$):INPUT#3,B$:N2=VAL(B$)
30454 N1=(INT(N1*10))/10:N2=(INT(N2*10))/10
30455 INPUT#3,B$:INPUT#3,B$:REM DUMMY BYTES
30460 FORTC=0 TO 1799
30470 IF RIGHT$(STR$(TC),1)="0"THENPRINT".";
30480 INPUT#3,B$:SA%(TC)=VAL(B$):INPUT#3,B$:RA%(TC)=VAL(B$)
30485 IF SA%(TC)=-1THEN TC=1801
30490 NEXT TC
30491 PRINT
30500 INPUT#15,ER$,EN$,TR$,BL$:IFVAL(ER$)>19 THEN GOTO 36000:REM DISC PROB
30505 CLOSE3:CLOSE15
30530 RETURN
36000 PRINT:PRINT"******DISC PROBLEM******"
36020 PRINT "ERROR NUMBER ";ER$,EN$
36030 PRINT:IF ER$<>"62"THEN GOTO37000
36040 PRINT"THE REQUESTED FILE COULD NOT BE FOUND"
36050 PRINT"ON THE DISKETTE.  PLEASE CHECK THE NAME"
36060 PRINT"AND BE SURE THE CORRECT DISKETTE HAS"
36070 PRINT"BEEN INSERTED."
36080 GOTO 38000
37000 PRINT"A SERIOUS DISKETTE PROBLEM HAS BEEN"
37010 PRINT"ENCOUNTERED.  THERE MAY BE DAMAGE TO"
37020 PRINT"THE DISKETTE OR PROBLEMS WITH YOUR"
37030 PRINT"DISKETTE DRIVE OR COMPUTER."
37040 PRINT:PRINT"CHECK APPENDIX 'B' OF THE 'VIC-1541"
37050 PRINT"SINGLE DRIVE FLOPPY DISK USER'S MANUAL'"
37060 PRINT"FOR FURTHER INFORMATION ON THE ERROR"
) PRINT"NUMBER LISTED ABOVE."
```

```
38000 PRINT:PRINT"PRESS ANY KEY WHEN YOU ARE READY TO"
38010 PRINT"CONTINUE..."
38020 GETB$:IF B$=""THENGOTO38020
38030 CLOSE3:CLOSE15:RETURN
40000 REM PRINT DETAIL ROUTINE*********
40010 L1$="    5    10    15    20    25    30    35    40    45    50    55    60"
40020 L2$="@"
40025 PRINT"{RV}        PRINTING...PLEASE WAIT!      "
40030 SP$="          "
40040 PRINT#4,CHR$(14)+"STUDENT";
40045 IFN1$<>""THENPRINT#4,": "+N1$+""+N2$:PRINT#4
40050 IFN1$=""THENPRINT#4,CHR$(15)+"":PRINT#4
40060 PRINT#4,CHR$(14)+"DATE/TIME";
40065 IFDT$<>""THENPRINT#4,": "+DT$;
40070 PRINT#4,CHR$(15)+"":PRINT#4
40080 PRINT#4,"TEST DURATION: "+STR$(S/3600)+" MINUTES":PRINT#4
40085 RS=1:RF=16:GOSUB20000:PRINT#4
40090 PRINT#4,"REINFORCEMENT DURATION FOR #1: "+STR$(D1/60)+" SECONDS"
40100 PRINT#4,"REINFORCEMENT DURATION FOR #2: "+STR$(D2/60)+" SECONDS":PRINT#4
40110 PRINT#4,"RELAY(S) ACTIVATED BY #1: ";
40112 FORB=0TO7:IF(R1%AND(2^B))>0THENPRINT#4,(B+1);
40113 NEXTB
40114 IFR1%=0THENPRINT#4,"NONE";
40115 PRINT#4
40120 PRINT#4,"RELAY(S) ACTIVATED BY #2: ";
40122 FORB=0TO7:IF(R2%AND(2^B))>0THENPRINT#4,(B+1);
40123 NEXTB
40124 IFR2%=0THENPRINT#4,"NONE";
40125 PRINT#4:PRINT#4:PRINT#4
40200 FORMC=0TO(S/3600)-1
40210 PRINT#4,CHR$(14)+"MINUTE"+STR$(MC+1)
40220 PRINT#4,CHR$(15)+SP$+L1$+" SECONDS"
      PRINT#4,SP$+L2$
```

```
40240 PRINT#4,"SW #1:    ";
40250 S1=0:FG=0
40260 FORPC=0TO59
40270 IFFG=0THENA%=SA%(PC+MC*60)
40280 IFA%=-1THENA%=0:FG=1
40290 A%=A%AND15:IFA%=0THENPRINT#4,"";:GOTO40400
40300 PRINT#4,RIGHT$((STR$(A%)),1);:S1=S1+A%
40400 NEXTPC
40410 PRINT#4,CHR$(16)+"71="+STR$(S1)
40420 PRINT#4,"SW #2:    ";
40430 S1=0:FG=0
40440 FORPC=0TO59
40450 IFFG=0THENA%=SA%(PC+MC*60)
40460 IFA%=-1THENFG=1:A%=0
40470 A%=(A%AND240)/16:IFA%=0THENPRINT#4," ";:GOTO 40500
40480 PRINT#4,RIGHT$((STR$(A%)),1);:S1=S1+A%
40500 NEXT PC
40510 PRINT#4,CHR$(16)+"71="+STR$(S1)
40520 FG=0
40530 PRINT#4,"REINF#1: ";
40540 FORPC=0TO59
40550 IFFG=0THENA%=RA%(PC+MC*60)
40560 IFA%=-1THENFG=1:A%=0
40570 A%=A%AND1:IFA%=0THENPRINT#4," ";:GOTO 40600
40580 PRINT#4,"";
40600 NEXTPC
40605 PRINT#4," "
40610 FG=0
40620 PRINT#4,"REINF#2: ";
4[illegible] FORPC=0TO59
```

```
40640 IFFG=0THENA%=RA%(PC+MC*60)
40650 IFA%=-1THENFG=1:A%=0
40655 IFPC=0THENA%=1
40660 A%=A%AND16:IFA%=0THENPRINT#4," ";:GOTO 40700
40670 PRINT#4,"";
40700 NEXTPC
40800 PRINT#4," "
40810 PRINT#4,SP$+L2$:PRINT#4:PRINT#4
40900 NEXT MC
40905 POKE 54276,32:POKE54276,33
40910 PRINT"{CU}{RO}                                        {CU}"
40920 RETURN
50000 REM DISPLAY CATALOG ROUTINE
50005 PRINT:PRINT"INSERT YOUR DISKETTE AND PRESS ANY KEY"
50006 PRINT"WHEN YOU ARE READY....."
50007 GETB$:IFB$=""THEN50007
50008 PRINT"{SC}PRESS SPACE BAR TO STOP LISTING, OR"
50009 PRINT"ANY OTHER KEY TO PAUSE LISTING"
50010 OPEN 15,8,15
50020 PRINT#15,"I0":OPEN4,8,0,"$0":NU$=CHR$(0)
50030 GET#4,A$,A$
50040 GET#4,A$,A$
50050 IFA$=""THEN50140
50060 GET#4,A$,B$
50070 PRINTASC(A$+NU$)+ASC(B$+NU$)*256;
50080 GET#4,A$
50090 IFA$=""THENPRINT:GOTO50040
50100 PRINTA$;
50110 GETA$:IFA$=" "THEN50140
50120 WAIT197,64
50130 GOTO50080
50140 PRINT:CLOSE4:CLOSE15:RETURN
READY.
```